Before the

Federal Communications Commission

Washington, D.C. 20554

In the Matter of	)	
	)	
AMENDMENT OF PART 97 OF THE	)	
COMMISSION'S RULES GOVERNING THE	)	RM-11392
AMATEUR RADIO SERVICE TO	)	
IMPLEMENT CHANGES TO SECTION 97.3(c)(2),	)	
97.221 AUTOMATICALLY CONTROLLED	)	
DIGTAL STATION	)	
97.305 AUTHORIZED EMISSION TYPES,	)	
97.307 EMISSION STANDARDS, AND	)	
97.309 RTTY AND DATA EMISSION CODES.	)	
	)	
	)	
	)	
	)	

To: The Chief, Wireless Telecommunications Bureau

Reply Comments

Mark Miller Amateur Radio Operator N5RFX, pursuant to Section 1.405 of the Commission's Rules, 47 C.F.R. 81.405, and pursuant to the Public Notice*,* Report No. 2828-Correction, released December 18, 2007, hereby respectfully submits my reply to the comments filed in response to the above Petition for Rule Making filed by Mark D. Miller on March 27,2007. The petitioner requests that the Commission issue at an early date issue a Notice of Proposed Rule Making, proposing changes in the rules governing the Amateur Radio Service in order to enumerate bandwidths in the current RTTY/Data subbands along with the current

ITU emissions designators, and to clarify what is an automatically controlled digital station. In reply to the arguments and suggestions contained in comments filed thus far, I reply as follows.

1. Emergency Communications

Many opposition comments cite that this petition would adversely affect emergency communications. The comments generally center around the timely delivery of messages. None of the comments in opposition defined the time requirement for delivery of messages and failed to provide detailed explanations of the time delays encountered from limiting emissions to the requested necessary bandwidths in the petition. I am unable to assess either the validity of these claims or how this adversely affects emergency communications. The commission would seem to be in the same predicament. Emissions that exceed the requested necessary bandwidths in the petition have typically been used to deliver email[1]. In general, email delivery times have less to do with the speed of transmission and more to do with the originators construction, and the recipient's available time to sort and read them. It is important for emergency communicator to understand that during an emergency, the commission's rules do not prevent the use by an amateur station of any means of radiocommunication at its disposal to provide essential communication needs in connection with the immediate safety of human life and immediate protection of property when normal communication systems are not available.[2] The commission's rules do

[1] See Michael Elliott comments
[2] 97.403

not prevent the use by an amateur station in distress of any means at its disposal to attract attention, make known its condition and location, and obtain assistance, nor do they prevent the use by a station, in the exceptional circumstances describe above of any means of radiocommunications at its disposal to assist a station in distress.[3] The commission's rules during an emergency would not make bandwidth or frequency selection a limiting factor during an emergency. Comments such as Pactor 3 and Winlink 2000 are often the only thing left after an infrastructure has been destroyed or is otherwise unavailable ignore the fact that this petition does not ask the commission to remove Winlink 2000 or Pactor III from the Amateur radio bands[4]. The discussion of Pactor III in the petition is there to show the commission that the most robust Pactor III speed levels will still be available, and that the higher speed levels are not spectrally efficient and are not appropriate for a shared spectrum service such as Amateur radio. If in fact Pactor III is invaluable for emergency communications, then the served agencies should consider asking the commission for licensed channelized spectrum, which is ideal for the Pactor III protocol, or the operations that use Pactor III should continue to move their operations to the Military Affiliated Radio System. Other comments have been made about the affect that this petition would have on the Emergency operations conducted by the Military Affiliated Radio system[5]. Since this is a United States Department of Defense sponsored program and since part 97 of the commissions rules do not regulate this activity this petition does not seek to address the operation of this organization.

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[3] 97.405
[4] See Steve Waterman comments
[5] See Grant Hays comments

2. Digital Data Technology

A majority of comments in opposition to the petition cite that the petition seeks to destroy digital data technology advancement in the Amateur Radio Service[6]. The petition does not ask for elimination of any emissions designators listed in 97.3(c). All modes using these emissions designators will still be authorized if the petition is granted. What the petition does seek is removing references to Baud rates and shifts, and replacing those references with bandwidth limits. Many comments in opposition agree with the removal of the Baud rate references[7]. The bandwidth limits asked for in the petition were derived by converting Baud rate and shift limits currently in 97.307(f)(3) and 97.307(f)(4) to bandwidths using the necessary bandwidth formulae in Part 2.202 (g) table of necessary bandwidths. Many opposition comments specifically refer to the elimination of Pactor III. Pactor III would continue to be authorized, as long as speed levels 1 and 2 are used.[8] Olivia, MT63, ALE, OFDM, fast PSK, MFSK were mentioned in the opposing comments[9]. These protocols all have configuration parameters or versions that would allow their continued use in Amateur radio spectrum. MFSK has a necessary bandwidth of 350 Hz and would not be affected by this petition. One commenter suggests that as the world moves into more complex, efficient, and higher speed protocols[10], the Amateur service will be viewed as antiquated if it does not also produce such

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[6] See John W Farnham comments
[7] See Bonnie Crystal and Steve Waterman comments
[8] Speed levels 1 and 2 are independent sub-protocols with distinct modulation and channel coding

[9] see Walt Witherington comments
[10] See Steve Waterman comments

protocols, and operations that support them. This petition enables the Amateur service to do just that by removing Baud rate and shift restrictions. The only objection it seems is to the enumeration of a maximum necessary bandwidth. The bandwidths suggested in the petition are those that are consistent with a shared spectrum service and specifically subbands in the MF and HF spectrum that are specifically intended for narrow bandwidth emissions. Digital communications do not perform efficiently in the presence of interference. In a shared spectrum service, the bandwidth digital bandwidth must be limited for the benefit of all users of the spectrum. The commission should seek specific comments through an NPRM that specifically address these concerns.

3. Installed Base of Amateur Radio Equipment

A majority of comments in opposition to the petition cite that the petition if granted would render useless a huge installed base of Amateur radio equipment[11].   None of the comments listed what specific equipment would be rendered useless.   Since the petition does not ask for elimination of any emissions designators listed in 97.3(c), no Amateur radio equipment would be rendered useless. An example is Pactor III equipment. There is only one maker of Pactor modems, and these modems are capable of using many protocols[12] that would continue to be authorized if the petition is granted[13]. The commission should seek specific comments through an NPRM that specifically address these concerns.

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[11] See Ken Anderson comments
[12] PACTOR™ is a registered trademark of SCS GmbH & Co. KG, Hanau, GERMANY
[13] See Nathan Bargmann comments

4. International Communications Standards

A majority of comments in opposition to the petition cite that the petition if granted, would put U.S. radio Amateurs at a disadvantage because some international communications standards would not be authorized. One standard cited by David McGinnis is MIL STD 110A. As Mr. McGinnis states, "because of a 2400 baud symbol rate, US Amateurs are already restricted from using the MIL STD 110A waveform."[14] This was the reasoning behind removing the current Baud rate and shift limitation and converting this into a bandwidth limit[15]. Communications protocols that are currently not authorized would remain not authorized. Emissions that will not be authorized are those that exceed the bandwidth limits that are currently enumerated, and those that exceed the bandwidth limits asked for in the petition that are derived by converting Baud rate and shift limits currently in 97.307(f)(3) and 97.307(f)(4) to bandwidths using the necessary bandwidth formulae in Part 2.202 (g) table of necessary bandwidths. James L. Randall in his comments states: "petitioner seeks to eliminate legal and necessary operations that have provided substantial benefit to the nation and to the world in times of disaster. An action by the FCC would not eliminate these emissions from the amateur bands, as the mode is legal throughout the world." Mr. Randall is correct that the commission does not regulate the world. The U.S. has a large number and a high density of Amateur radio operators. What regulators do in other countries may not be appropriate for the U.S. The

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[14] See David McGinnis comments
[15] See 97.307(f)(3) and 97.307(f)(4)

commission should seek specific comments through an NPRM that specifically address these concerns.

5. Automatically Controlled Data Sub-bands Too Narrow

Many comments ask for an increase in the frequency spectrum for automatically controlled digital stations[16]. No analysis was offered as to why this should be granted. Granting the request of the petition would decrease the spectral occupancy of modes now exceeding the requested necessary bandwidths and will increase the number of stations that can occupy these subbands. The commission set aside these subbands in order to mitigate interference to the communications of other amateur stations. In the Report and Order authorizing automatic control in the HF bands, the commission justified the spectrum allocated in the automatic control subbands by stating that the bandwidth of transmission of an automatically controlled station will occupy no more than 500 Hz.[17] Restoring bandwidth limits in the RTTY/Data subbands is consistent with the commission's report and order.

6. VHF/UHF/SHF weak signal areas

Two comments point out that Appendix A has errors, which affect the 70 cm and shorter wavelength bands.[18] I agree with this comment and have submitted an errata to Appendix A correcting this error.

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[16] See Gerald Manthey comments
[17] Report and Order PR Docket 94-59 paragraph 7
[18] See James R. Maynard and John Bolt Stephensen comments

7. Spectrum Efficiency Calculations

Comments were made as to the analysis of the spectral efficiency of Pactor III (PIII) vs. Pactor II (PII). Richard W. Ferguson in his comments points out an error in the petition. Mr. Ferguson states, “ I suspect that Mr. Miller’s error may have been due to the equation he was using. The equation he is referring to is “The spectral efficiency was derived from dividing the occupied bandwidth by the usable data rate.” Mr. Ferguson is correct that the statement should have been “The spectral efficiency was derived from dividing the usable data rate by the occupied bandwidth.” The spectral efficiency in Tables 2 and 3, and Figure 3 were calculated by dividing the usable data rate by the occupied bandwidth. Mr. Ferguson is correct that the higher the number, the more efficient the mode. I have checked the calculations and they are correct. With this confusion an explanation of table 3 is in order. The PII spectral efficiency was calculated by adding a 100 Hz guard band to either side of the PII occupied bandwidth. This was done to show that two PII emissions could be placed in the occupied bandwidth of 1 PIII emission. It would not be proper to make a comparison based on PII emissions that had no guard band spacing. Eliminating the guard band spacing would inflate the spectral efficiency of PII. John W Farnham states, Petitioner used firmware version 3.6, and the current version is 3.8. Mr. Farnham claims that “The newer firmware improves the performance of PACTOR 3, improving s/n performance, enhancing data rate and robustness and improving spectral efficiency”, yet he offers no analysis to back up his claim. The data I provided was derived from the RF_Footprints Rick Muething analysis and from Edwin C.Jones (AE4TM). The commission should seek specific comments through an NPRM that request comments and new studies to confirm the improvements in Pactor III version 3.8. Another comment states that “Mr. Miller has no details of specifically how the measurements were made, what the power level, crest factor or bandwidth levels used were. He made no attempt to contact me with questions or clarifications about the tests and included only my summary document that was part of a presentation at ARRL/TAPR DCC 2004”[19]. I offer to the commission email proof in Appendix A of these reply comments that contact was made, and that Mr. Muething and I had email conversations about his measurements in appendix A. In appendix A the email chain clearly shows that Mr. Muething did in fact provide details of the tests that were performed. Mr. Muething also agreed with my spectral efficiency analysis by stating that “I agree that P2 and P3 are closely comparable in spectral efficiency”. I am confident that Mr. Muething did not recall these email conversations that occurred in December of 2006. It also should be noted that the commission filed RM-11392 on March 27th 2007 shortly after my contact with Mr. Muething. Mr. Muething also in his comments provided the documentation RF Footprints that I also provided to the commission in Appendix C of the petition. Mr. Muething also states that PactorIII speed does not increase from 500 Hz to 2200Hz. I refer the commission to the statement in appendix B “The PACTOR-III Protocol Document” in section 6 on page 5 that states that the FSK PACTOR standard is used for the initial link establishment. The FSK PACTOR standard has an occupied bandwidth of approximately 500 Hz. Pactor III

[19] See Gerald F. (Rick) Muething, Jr comments.

8. Commercial Protocol

Two comments refute the statement made in the petition that Pactor III was developed for commercial markets[20]. I would refer the commission to appendix B of the petition. In appendix B "The PACTOR-III Protocol Document" authored by Hans-Peter Helfert, and Dr. Thomas Rink of SCS GmbH & Co. KG, Hanau, Germany supports the statement made in the petition. Mr. Waterman also states that the petition suggests that those individual stations participating in the Winlink 2000 system are operating as commercial entities. I can find no statements to that effect in the petiton.

9. Conclusion

Therefore, the foregoing considered, I Mark Miller again respectfully request that the commission issue a Notice of Proposed Rule Making at an early date, looking forward to the adoption of rule changes set forth in the amended Appendix A.

Mark D. Miller N5RFX

[20] See Steve Waterman and Gerald F. (Rick) Muething, Jr comments

Appendix A

Email correspondence with Rich Muething

From: "Rick Muething" <rmuething@cfl.rr.com>
To: "'Mark Miller'" <kramrellim@tx.rr.com>
Subject: RE: RF Foot Prints
Date: Sat, 9 Dec 2006 11:07:46 -0500
X-Mailer: Microsoft Office Outlook 11
Thread-Index: AccbSbn45kmqYOUyT8C6DQBvwY/evAATjJkw
X-Virus-Scanned: Symantec AntiVirus Scan Engine

Mark,

Thanks for your interest and comments. Its been about 2 years since I worked
on that slide....so some of this comes from memory.

I didn't use the max throughput values for Pactor I, II or III. Pactor I is 200 bits/sec Pactor II is about 800 bits/sec and P3 about 3600 bits/sec. Although I can't find my original calculation I used some average of the available throughput. From experience of many years using P1, P2 and P3 on
the air and in tests on an HF simulator it is very rare when a HF channel will support the maximum throughput that the mode allows. Max throughput also requires (especially in the case of P2 and P3) good flat IF filtering in the receiver and good matching/tuning of the Receiver pass band to the signal.

So based on the values I used for P2 and P3 my recollection is that they are about 1/2 the max rates with perhaps a little boost to P1 since it calculates out to 12.5 characters per second at 1/2 max rate.

Re the S/N and bandwidths: Certainly it might seem best to plot S/N in the actual bandwidth REQUIRED for the mode. There are at least two reasons why
this is not usually done:

1) Most simulators (both hardware and software) add noise based on a 3 KHz noise bandwidth. They essentially take the total average power of the signal and then add noise (3KHz bandwidth) to make the desired S/N in a 3KHz
bandwidth.

2) In practice it is very difficult to provide the optimum receive

bandwith for the signal. This due to tuning errors and guard bands (remember
there is no manual tuning typically in a message system) , receiver IF filter "fit" and flatness, drift etc. As a result there is usually significantly more audio noise than is in the true occupied bandwidth for the mode. The use of a standard 3 KHz noise bandwidth makes these estimates,
calculations and adjustments unnecessary. Of course most TNCs also have some
form of audio noise filtering (DSP or Analog) before the detection hardware or software. The measurements that I showed using the Simulator were with a
real TNC (PTC II) with very good DSP audio filtering. So the actual S/N levels after audio filtering (IN THE OCCUPIED BANDWIDTH) are actually different than in the graph....P1 and P2 in these cases are actually about 6-7 db or so better (higher S/N) than P3 if you are comparing S/N in the "occupied" bandwidth.

The crest factor of a mode (the ratio of the Peak RF to the average RF) primarily limits the average RF that a given transceiver can output. Pactor I has a crest factor of about 1 since it is truly FSK. P2 and P3 have phase modulation (P3 on many sub carriers) so their crest factor is > 1 and the average power available (before distortion) from say a 100 watt PEP transceiver is less. As you know you absolutely cannot have clipping or ALC on these higher crest factor modes without significant splatter. This whole crest factor discussion however is also modified by what limits the maximum RF output. So it depends on whether you are transceiver PEP limited or DC power (e.g. battery capacity) limited. So for example a Pactor I signal CF= 1 can drive a typical Ham transceiver to about 100 Watts PEP with an actual energy output of near 100 watts. But a P3 signal with a crest factor of 3:1 will only achieve (and consume) an energy of about 33 watts before hitting the same transceiver peak limit of 100 W PEP. There is one further factor to throw in here too. Most amateur transmitters are not RATED for continuous PEP output. The typical 100 Watt PEP transceiver probably starts to overheat
at continuous power output of perhaps 25-40 watts. Since Pactor can transfer long files (high duty cycles) it is usually essential to limit the average power out of an amateur transceiver to between 25 - 40% of its rated PEP independent of the mode (RTTY, PSK, P3 etc). (One reason that most 100 W PEP
transceivers limit AM output to about 25W)

In the tests that I did with the HF channel simulator (the results presented on the slide) there was no "RF" involved at all. The HF Channel simulator basically computes the average audio power level and then adds the appropriate noise power to that. In practice this is saying that the RF output level is limited by average power (thermal) considerations and therefore is independent of crest factor. I think this is pretty true for most amateur RF Transceivers. (You can run P3 at 100 W PEP and with its crest factor it averages about 33 watts....You CAN run P1 at near 100 watts AVERAGE on the same 100W PEP transceiver...(but not too long!) but if you consider thermal limitations and duty cycle you will probably have to limit P1 to about 33 watts average too....the same average power as P3).

So as you can see it is very easy to get pulled into many complicating and confusing factors in this kind of analysis and in doing leave most of us in the techno dust! What I tried to do with the simple slides and RF Footprint discussion was keep it reasonably accurate and present the data as it is usually presented and what most hams could easily interpret. If you really want to do and present an accurate engineering analysis on this you have to identify the other factors and make the appropriate assumptions as I have mentioned above.
Namely:
1) Is the transmit power limited by PEP, DC (Battery) capacity, or Thermal (duty cycle) considerations. Normally one of these will dominate but it is possible that depending on the mode's crest factor the limits could be different for different modes on the same transceiver.

2) Are you talking about Peak S/N ratios or average S/N for high crest factor modes? What is the interval you use to compute "average" power. Over what bandwidth is the noise energy is calculated?

3) How well matched is the receiver bandwidth to the mode? Does this include the required guard bands to handle tuning errors, IF filter "fit", offsets or drift?

4) Are you plotting S/N in a fixed (e.g. 3 KHz) bandwidth or a variable (e.g. occupied) bandwidth?

5) How much (and how good!) is the audio filtering of the TNC before the detection. This along with what your S/N bandwidth is can have some significant (perhaps 6-8 db) impact on the True S/N. The complicating factor here is now you also have to involve what TNC is used so it adds yet another variable to what started as a basic mode comparison. This is why on my tests I used ONE TNC (the same PTC II) for all tests on P1, P2 and P3. It is also why I averaged the results of 4 HF channels (WGN, Multipath poor, Multipath
good, flat fading).

To be completely accurate in computing the true RF footprint you also have to make assumptions of the overhead (in time) with setting up the link and exchanging the forwarding information and how fast the mode ramps up speed
based on channel conditions. For example if you have only one very short message P3 would not show to its full advantage due to the overhead of many link turnovers and associated overhead of proposal negotiations. However a long binary file ...e.g. a large compressed message, or fax image becomes more efficient allowing P3 to "ramp up" to the full throughput speed that can be supported by the HF channel.

Having been an engineer for many years the biggest challenge is still how do you include and present the all the necessary details without getting the analysis so complex and cluttered up no one can follow it!

Your comments and thoughts welcome.

73,

Rick KN6KB

-----Original Message-----
From: Mark Miller [mailto:kramrellim@tx.rr.com]
Sent: Friday, December 08, 2006 11:23 PM
To: rmuething@cfl.rr.com
Subject: RF Foot Prints

Rick,

I was reading your RF Footprints presentation at http://www.winlink.org/Presentations/RFfootprints.PDF . I have some questions for you. First on page 4 I think you are saying that Pactor II has a throughput of 50 characters per second and Pactor III has a character throughput of 225 characters per second? I don't quite follow this since the maximum throughput of Pactor II 700 bit/s and the maximum throughput for Pactor III is 2722.1 bits per second. The ratios don't match. I think you took a little too much away from Pactor II don't you think?

Also on page 5 you are plotting S/N ratio to throughput for the three Pactor types @ 3Khz bandwidth. What were the RF levels necessary to achieve the signal to noise ratios that are shown? It would seem because of the crest factor differences, that P1 and PII require less

RF energy to achieve an equivalent S/N ratio with PIII. The S/N
ratios don't tell us much especially since the sensitivity of each
mode appears to be equal when given in terms of S/N ratio. I suspect
that the RF levels are not equal..

Please let me know if you have more detail on these tests. They are
very interesting.

73,

Mark N5RFX

From: "Rick Muething" <rmuething@cfl.rr.com>
To: "'Mark Miller'" <kramrellim@tx.rr.com>
Subject: RE: RF Foot Prints
Date: Sat, 9 Dec 2006 14:23:32 -0500
X-Mailer: Microsoft Office Outlook 11
Thread-Index: Accbs0ck29HZSb5vQlKdUi12TYVjLgABb7PQ
X-Virus-Scanned: Symantec AntiVirus Scan Engine

Mark,

I am not sure I agree with you on continuous duty ratings for amateur transmitters. PEP the Peak Envelope Power rating is a function of the design of the transmitter output stage with concern for linearity. The typical 100 W PEP rating of most transmitters is the peak envelope that will not cause distortion beyond the required specs. BUT continuous duty means it could sustain for example a continuous output carrier (100 % duty cycle) and most amateur (and most marine SSB too) transmitters are rated for ICAS (Intermittent Commercial and Amateur Service) and will NOT sustain a full time 100 Watt average power in any low crest factor mode (CW, FSK, FM, AM).
To achieve continuous duty operation would normally require using a transmitter with a more stringent CCS (Continuous Commercial Service) rating. I have seen a Pactor transmission last 30 or more minutes with very large files and this is near continuous (> 90% transmit on time) duty...most amateur rigs would burn up or employ their auto over temp shut down or power
down. At any rate regardless of specs, we that have run PMBOs on pactor for many years are very careful to not run the rigs at max output on low Crest factor modes. (e.g. the Pactor I audio drive on a PTC II is usually set below the P2/P3 audio drive) to reduce average RMS power out (heating) on P1
channels....Some of us learned this the hard way with burned up finals or

antenna tuners/relays.

If you are comparing P1,P2, P3 S/N levels in a common (e.g.3 KHz) fixed bandwidth then the S/N ratios will be the same if the three modes are run at the same AVERAGE power out....That is the heating power (RMS) of the RF signal not necessarily the same PEP of course. I contend that while P1 can be run at higher power (due to the low crest factor) on most transmitters in practice that power is usually limited by the thermal considerations at high duty cycles more so than the PEP limit. Therefore in practice you generally run all three modes (and also modes like RTTY, Domino, PSK etc) at lower than max output to reduce thermal loads or DC/Battery requirements. This tends to balance out the crest factor.

Your comment:
"What I get from this is that to achieve equal signal to noise ratios between P1, PII and PIII, P1 and PII will require a lower PEP than PIII"

Is correct...the S/N is generally computed on the average (RMS Heating) power so the PEP ratios for the same average power will vary as the Crest factors: e.g. for the same heating power P1 (CF = 1.0) will need about 1/3 the PEP output of P3 (CF ~ 3) .... both will have the same average power output and the same average S/N. If you want to convert the S/N in a 3 KHz bandwidth to the S/N in the occupied bandwidth you will have to adjust it by the bandwidth factor: for P3 that is about 1.3 dB (10*Log(2200/3000)) and for P2 about 8.2 dB (10*log(450/3000)) . So if P3 and P2 had the same average (heating) power and the same S/N in a 3 KHz bandwidth P2 would actually be operating at a S/N in the OCCUPIED bandwidth of 6.9 dB (8.2 - 1.3) higher than P3. But as I said before to gain that 6.9 dB requires exactly positioning the correctly shaped filters for both modes...not always that practical with required guard bands etc. Also remember that S/N is only one factor affecting throughput....multipath, fading, adjacent channel interference etc also contribute and their effects do not necessarily track 1:1 with S/N.

It has been a while since I looked at the details of bandwidth vs. Speed level for P3 and your numbers may be correct. In practice P3 runs at an average of 1400-2800 bits/sec (before any binary compression which in the case of Winlink is always used) I would say a good average figure for P3 is 1400 bits/sec (175 char/sec). this is roughly 4x the average speed for P2 and 16x the average speed of P1 given the same signal strength. Those 4x and
16x numbers are based on an average of a large number of observations using stats gathered by WL2K.

I have been working on some sound card modes (currently 450 Hz bandwidth using both Domino and 9 carrier PSK modulation). One of the goals of a good mode is to use the bandwidth as effectively as possible. That is why most modes (including P3) do not try to reduce the bandwidth too much at the slower speeds ...more robustness (especially during poor multipath conditions) is usually better achieved using a wider bandwidth and slower symbol rates. Since these Smart modes are auto adapting varying the bandwidth excessively during the connection invites additional interference from adjacent channels.

I am not sure where you are heading with all this... I suggest if you are trying to make a point or present a comparison you consider and understand all the factors and also try and have at least another set of engineering eyes look at it. It is easy to make some inappropriate assumptions or omissions and I have seen arguments made that are very easily and quickly dismissed by those that really understand this issue. In the final analysis

It is hard to beat actual A/B comparisons based on actual measurements under
controlled conditions such as a HF channel simulator which is why I used that in my initial presentation. While over-the-air mode comparisons might be fun...the channel is usually so variable the resulting observations are at best qualitative and rarely yield good engineering data. There is a free Ham software channel simulator (works on audio files) called PathSim by Moe
Wheatley AE4JY (http://www.qsl.net/ae4jy/pathsim.htm) . It is not as nice as some commercial programs or hardware simulators but it can do the job if you
are willing to use and convert .wav files that it processes. It will give you more consistent results than any over-the-air tests.

Good luck,

Rick KN6KB

-----Original Message-----
From: Mark Miller [mailto:kramrellim@tx.rr.com]
Sent: Saturday, December 09, 2006 11:56 AM
To: Rick Muething
Subject: RE: RF Foot Prints

Rick,

Thanks so much for your explanation. I will have to read it very carefully to make sure I understand; but, I did get one answer that I was looking for and that is how the S/N ratios are computed. What I get from this is that to achieve equal signal to noise ratios between P1, PII and PIII, P1 and PII will require a lower PEP than PIII. I understand your thoughts about transceiver PEP, but most modern rigs that I am familiar with do have a continuous duty PEP rating. This was achieved for the most part by sacrificing linearity, which in the P1 case does not cause a problem, but can cause problems with PII and PIII.

It would be interesting to know the average speed level (SL) of PIII. From reading the specification, it seems that the bandwidth of PIII is dependent on speed level.

1 1000 HZ
2 1480 HZ
3 1720 HZ
4 1720 HZ
5 1960 HZ
6 2200 HZ

From your experience, is this correct?

Thanks again and 73,

Mark N5RFX

At 10:07 AM 12/9/2006, you wrote:
>The HF Channel simulator
>basically computes the average audio power level and then adds the
>appropriate noise power to that.

From: "Rick Muething" <rmuething@cfl.rr.com>
To: "'Mark Miller'" <kramrellim@tx.rr.com>
Subject: RE: RF Foot Prints
Date: Sat, 9 Dec 2006 20:05:16 -0500
X-Mailer: Microsoft Office Outlook 11
Thread-index: Accb1XNQQJTQpnqCTvSrPM+U+DFxOgAGg1kg
X-Virus-Scanned: Symantec AntiVirus Scan Engine

Mark,

I agree that P2 and P3 are closely comparable in spectral efficiency (usually stated in terms of bit/sec/Hz bandwidth. There is a reason for that.... basically related to Claude Shannon's theorem stating that the theoretical throughput of a channel is intimately related to the S/N. Pactor II and III are getting reasonably close (perhaps a few dB) to the Shannon Limits. There are some better coding schemes available today (e.g. turbo codes) that can do somewhat better ...perhaps within 1 dB or closer to the Shannon limit.... We should be working on that now...it will help and you can bet (though I have no inside info to suggest this) ....that SCS and others are working on new modulation and coding schemes along those lines.

BUT and this is important ...you cannot ignore the guard bands just because they contradict your argument! In any message system that relies on the accuracy of tuning and the ability of recognizing and capturing a signal that is off freq, drifts, or is not perfectly centered in the receiver pass band you HAVE to have guard bands. Just because for example a pactor II signal is 450 Hz wide does not mean you can space QSOs at 450 or even 500 Hz. The same is true for SSB, PSK31 and most other modes. Today's typical modern transceivers are only accurate to say +/- 50 Hz...perhaps better if they include a well calibrated TCXO. The filters...even good DSP based filters do not have infinite adjustability (my new TX-480 has filter steps of 100 Hz). Remember when a mode is designed, implemented and deployed it
is intended that most amateur equipment can work with it ...not just the $4000+ top of the line transceiver. The truth is that the narrower the mode the more the necessary guard bands increase the effective bandwidth...the minimal spacing of adjacent channels that the mode takes. To ignore this is just not reality and not consistent with how we really use amateur radio in a non-channelized and limited accuracy world.

Finally I strongly disagree with one point your raise...that in good conditions a mode should reduce the bandwidth...rather it should keep the bandwidth nearly constant and in good conditions increase the data rate. The conditions (e.g. S/N) dictate the theoretical bits/sec/Hz throughput... What we want is to operate as close as possible to that theoretical throughput limit. The whole point of a metric like my RF footprint assumes we have a message of size X to move...now we want to move it with the minimal bandwidth (including guard bands) time product ...that is what spectrum utilization is. Dropping the bandwidth because the conditions are good doesn't change the theoretical bits/sec/Hz throughput and because of necessary guard bands would actually decrease the net spectral efficiency thus increasing the RF footprint! In addition as I mentioned having a mode that dynamically varies the bandwidth based on conditions just invites adjacent channel interference.... How close do you space variable bandwidth modes? A much better approach would be in good conditions to increase the throughput (bits/sec) keeping the bandwidth constant (obviously at he expense of robustness) and complete the transfer earlier while keeping the bandwidth nearly constant.

I am not sure of your background in all this but I think you are getting confused somewhat about throughput (bits/sec) robustness and S/N. These as I mentioned earlier are all well known and well predicted quantities thanks to Mr Shannon (work done in the early 1950s!!!) If you are not familiar with his basic theorems it would be worthwhile looking into. What we as amateurs
need to do is figure out how best to fit his theories into the modern DSP world we now live in and optimize our mechanisms for moving data, voice, etc over our airways.

Pactor III or Pactor II are certainly not perfect...we can and we should do better though it is not easy work...(I know that from a lot of experience).
I think there are lot of opportunities here (e.g. low bandwidth digital voice based on synthetic speech) to work on but trying to say P3 is bad just because it is wider (though still nearly the same bits/sec/Hz BW spectral efficiency as the best digital modes) to me is not a sound argument. If we really want to work on spectral efficiency we need to look closer at the real culprits...e.g. 300 Baud HF packet, AM Phone etc) and we need to work on modes that will dynamically adjust throughput in a constant bandwidth channel based on the dynamics of S/N and channel distortion.

Rick KN6KB

-----Original Message-----
From: Mark Miller [mailto:kramrellim@tx.rr.com]
Sent: Saturday, December 09, 2006 4:03 PM
To: Rick Muething
Subject: RE: RF Foot Prints

Rick,

The amateur transceivers that I know can handle 100 watts continuos duty are the IIC 746, IC 746 pro, IC 756 (all models). I agree however that running these rigs at 50% of the rated power is a good idea especially to improve longevity.

Where I am heading with all of this is that PII is equally as spectrally efficient at PIII. I agree that adding more tones increases robustness, but the way that PIII employs its adaptive algorithm is flawed when used on amateur radio frequencies. If we were assigned channels like part 80 stations, then I think that PIII would be fine. When conditions are good, that is when PIII is at its widest, that is backwards from the way it should work on amateur radio. When conditions are good, the bandwidth should be narrowed, why do I need the robustness of a wideband signal? Of course all of this assumes that PII and PIII are equally spectrally efficient. I point to your graph on page 5. If I look at the chart and look at the +10 S/N ratio I see that PIII has a throughput of about 11334 bytes per minute and PII at 3000 bytes per minute for a PIII/PII ratio of 3.778. 11334 is 1511.2 bits per second, and that averages out to a throughput somewhere between SL 4 and SL5. The bandwidth of SL5 is 1960 Hz. PII througphut would be 8-DPSK modulation for a throughput of 400 bit/s. The PIII/PII ratio is 1960/500 or In this case is 3.92. The spectral efficiency of PII and PIII are nearly equal. I am not adding your guard bands. Adding the guard bands is the only way you can make PIII more spectrally efficient than PII. I belive the proper algorithm for amateur radio is to use PII until conditions are bad enough to warrant a change to PIII. Since PIII SL1 and SL2 are the most robust speeds, they are really the only speeds needed, and they have a bandwidth of 1000 and 1500 Hz respectively. That would be a much more responsible way to operate in my opinion. I really appreciate you talking this out with me.

73,

Mark N5RFX

From: "Rick Muething" <rmuething@cfl.rr.com>
To: "'Mark Miller'" <kramrellim@tx.rr.com>
Subject: RE: RF Foot Prints
Date: Mon, 11 Dec 2006 09:59:53 -0500
X-Mailer: Microsoft Office Outlook 11
Thread-index: Accc1U7bxS3ZjS+IRCCTLjzL6uIucQAWUF6g
X-Virus-Scanned: Symantec AntiVirus Scan Engine

Mark,

Your analysis and examples seem to agree pretty closely to theory.... You may have misinterpreted one of my earlier comments:
You said: "I missed this the first time and understand that the graph already shows S/N ratio for the narrower bandwidth."

This is not correct. The graph as labeled shows the S/N in a 3 KHz bandwidth for all modes. It is not adjusted for mode bandwidth. If you want to correct it for occupied bandwidth S/N you have to apply the correction factors I mentioned earlier 1.3 db for P3 and 8.2 db for P1/P2. So if you look at say the 5 db S/N (3KHz) point on the graph in the occupied bandwidth for each mode P3 is actually running at 6.3 dB S/N and P2 is actually running at 13.2 dB S/N.

Of course none of these analysis and discussions are specific to Pactor. As you keep the average power constant and reduce the bandwidth in any mode you
improve the S/N by the bandwidth reduction factor 3 db for each halving of the bandwidth. That is true for Pactor, SSB, CW or any mode. Also the crest factor of a mode is really just dependent on the modulation scheme used. CF = 1 will only be true for synchronous FSK modes like RTTY, Domino etc. All other modulation modes PSK, AM, SSB, QAM64 etc all employ some crest factor
and that is not necessarily bad though it ultimately places peak signal requirements on the transmitter. The fact is the theory and practice show that the other modulation modes (PSK, QAM etc) are superior (in terms of BER) to FSK when modern detection techniques are used.

There are two other very important factors about comparing digital modes of different bandwidth that are important.
1) With proper coding a wider band mode is less susceptible to errors due to selective fading and multipath. Pactor 3 and MT63's robustness comes partly from the frequency diversity of these wider modes. The ultimate example of this is of course spread spectrum which certainly has application but probably not in our HF bands.

2) Error coding definitely improves the performance and this takes additional bits... often up to 2-4 times the number of bits in codes with high coding factors (turbo codes). The advantage of a wide band mode is it is very easy and efficient to change the coding factor with the observed bit error rate (a function of the channel quality). And this is just what Pactor II and III do. When the condition is good the coding factor (and possibly also the modulation mode) is adjusted to keep the net overall throughput (after ARQ repeats) maximized. Modes like MT63, PSK31 etc which
have a fixed modulation and coding scheme don't do this which is one reason these are not optimal for message type systems (as opposed to limited speed keyboard QSOs).

Again what I think we need to promote in amateur radio is a better understanding of these theories and practices and to encourage those that have the ability to get in and play around with programming sound card modes. Two great books I have found on this (which do not require a heavy

math background) are Wireless Digital Communications Design and Theory by
Tom McDermott, N5EG and Understanding Digital Signal Processing Second Edition by Richard Lyons. I am saddened by the whining I so often hear about
SCS and their "proprietary" modes....Everything they do in P2 and P3 is well understood theory and well documented. All it takes is hard work (which they have done) to bring it to practice. It is sad that half a million hams world wide can't come up with something as good or better than P2/P3. Today's PCs are getting closer to the power of the dedicated DSP in boxes like the PTC II and it is possible with good software design to do high performance digital modes via the sound card.

OK I'll get off the soapbox!!!

Rick KN6KB

-----Original Message-----
From: Mark Miller [mailto:kramrellim@tx.rr.com]
Sent: Sunday, December 10, 2006 10:35 PM
To: Rick Muething
Subject: RE: RF Foot Prints

Rick,

At 10:07 AM 12/9/2006, you wrote:
>The measurements that I showed using the Simulator were with a
>real TNC (PTC II) with very good DSP audio filtering. So the actual S/N
>levels after audio filtering (IN THE OCCUPIED BANDWIDTH) are actually
>different than in the graph....P1 and P2 in these cases are actually about
>6-7 db or so better (higher S/N) than P3 if you are comparing S/N in the
>"occupied" bandwidth.

I missed this the first time and understand that the graph already shows S/N ratio for the narrower bandwidth. I did have a copy of PathSim and tried a couple of things with it. I don't have a PTCII so I used MixW and my Delta 44 soundcard to generate MT63 to represent a high crest factor mode, and RTTY to represent a low crest factor mode. I used Cool Edit pro to analyze the waveforms. The first file was RTTY:

RTTY

Min Sample Value: -3097
Max Sample Value: 3106
Peak Amplitude: -20.46 dB
Possibly Clipped: 0
DC Offset: -.002
Minimum RMS Power: -21.88 dB
Maximum RMS Power: -21.79 dB
Average RMS Power: -21.83 dB
Total RMS Power: -21.83 dB
Actual Bit Depth: 16 Bits

Using RMS Window of 1000 ms

The Peak amplitude is actually PEP. I determined this some time ago by generating 2, 3, and 4, equal tone signals and looking at the ratio of peak amplitude vs. Average RMS power. The ratios were 3 dB, 4.7dB, and 6 dB respectively which would indicate PEP to average ratios. The peak to average ratio for RTTY is near the 0 dB ideal. I there is a bit of an envelope when MixW generates AFSK rtty. I had PathSim generate a file that had a 20 DB S/N ratio. I earlier had it generate one with a 1004 Hz tone and fed that into my HP 4935A transmission test set, which has a distortion analyzer. The S/N ratio was with in 1dB of being correct. Pretty good I think. Here are the stats for the RTTY signals with a 20 dB S/N ratio.

RTTY 20 dB SNR
Min Sample Value: -7390
Max Sample Value: 7376
Peak Amplitude: -12.93 dB
Possibly Clipped: 0
DC Offset: -.003
Minimum RMS Power: -15.63 dB
Maximum RMS Power: -15.17 dB
Average RMS Power: -15.29 dB
Total RMS Power: -15.29 dB
Actual Bit Depth: 16 Bits

Using RMS Window of 1000 ms

The average power went to 15.29, which seems common to all of the files I manipulated with PathSim.. I then generated an MT63 signal with MixW:

MT63 Foxes

Min Sample Value: -3251
Max Sample Value: 3399
Peak Amplitude: -19.68 dB
Possibly Clipped: 0
DC Offset: -.002
Minimum RMS Power: -29.77 dB
Maximum RMS Power: -29.38 dB
Average RMS Power: -29.56 dB
Total RMS Power: -29.56 dB
Actual Bit Depth: 16 Bits

Using RMS Window of 1000 ms

The peak value of the original RTTY and MT63 signals are almost identical. The peak to average ratio of the MT63 signal is nearly 10 dB. The difference in RTTY/MT63 peak to average ratios is: 8.55dB. I had PathSim generate a MT63 signal with 20 dB SNR:

MT63 Foxes 20 dB SNR
Min Sample Value: -16824
Max Sample Value: 17961
Peak Amplitude: -5.22 dB
Possibly Clipped: 0
DC Offset: -.008
Minimum RMS Power: -15.86 dB
Maximum RMS Power: -15.09 dB
Average RMS Power: -15.27 dB
Total RMS Power: -15.29 dB
Actual Bit Depth: 16 Bits

Using RMS Window of 1000 ms

The average RMS power is the familiar 15 dB. So when I compare RTTY with MT63, PathSim does give me the same average power for both signals. The RTTY/MT63 peak to average difference with the 20dB S/N ratio is about 7.7 dB. The difference in peak amplitudes is around 7.7 dB. So if I were using a 100W PEP SSB transmitter and had an output of 100W PEP, I would have to reduce my RTTY PEP to 17 watts to produce equal average power and noise levels.. Using the graph on page 5, and the 10 dB S/N ratio again, PIII is somewhere between SL 4 and SL5. Assuming SL5, the crest factor is 5.2 dB. The crest factor for PII is 1.9. If I am running P3 at 100 watts PEP then I can run PII at 50 watts PEP and get the same signal to noise ratio. I could also run PIII at 50 watt PEP and PII at 50 watts PEP and get a 3 dB advantage for PII. You did mention that modes with a high crest factor require linearity. This is true. On my 746 and 746 pro, the best linearity occurs at 40 to 50 watts PEP. These rigs are pretty typical in this area. You mentioned the reason that 100 watt PEP transmitters limit AM carrier power to 25 watts is because of duty cycle. The reason why a 100 watt PEP transmitter has to limit carrier power to 25 watts is because at 100% modulation the PEP output of that transmitter is 100 watts, the average power is around 37.5 watts. The PEP to average ratio of AM is 4.3 dB. This is also the most linear area of most of these transmitters. This would be the case regardless of the duty cycle of the transmitter. Low level AM modulated transmitters with ALC operate this way. PII should also require linearity, so both PII and PIII should be run at 40 to 50 watts on the rigs I have mentioned, and PII will have a 3 dB advantage over PIII. The DSP in the PTCII should be able to give some advantage to PII, and I agree that is reflected in your graph.

73,

Mark N5RFX